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CIVIL ENGINEERS



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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

NOTICE OF REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY, MAY 19, 1915,

at 7.45 o'clock P.M., in CHIPMAN HALL, TREMONT TEMPLE, BOSTON.

Prof. Albert Sauveur of Harvard University will give a talk on "The Structure of Iron and Steel." He will exhibit lantern slides to show how the structure of steel is affected by various treatments and will also call attention to the usefulness of microscopical examination in metallurgy.

S. E. TINKHAM, *Secretary.*

PAPERS IN THIS NUMBER.

"Ground Water Supplies," W. S. Johnson.

(Presented February 17, 1915.)

Discussion of "The Economic Depth of Trickling Filters.

Discussion of "Insurance as an Aid to Engineers."

CURRENT DISCUSSIONS.

Paper.	Author.	Published.	Discussion Closes.
Elimination of Grade Crossings.	L. B. Reilly.	April.	Aug. 15.

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Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETINGS.

BOSTON, April 21, 1915. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at 8 o'clock by the President, Charles R. Gow. There were 79 members and visitors present.

By vote the reading of the records of the annual meeting of March 17 and the special meeting of March 31 were dispensed with and they were approved as printed in the April JOURNAL.

The Secretary reported for the Board of Government that it had elected the following to membership in the grades named:

Members — Messrs. Raymond W. Coburn, Gregory P. Connolly, Kenneth Tolman Corey, Ralph A. Doane, Arthur L. Gammage, Lucien E. D. Gaudreau, Francis Ingraham Greene, Oliver Perry Sarle, Malcolm Gayton Stocker, Philip W. Taylor, John Franklin Thomas, Edward Broughton Waite and William Austin Wood.

Juniors — Messrs. John E. Allen, Leroy Gile Brackett, Ernest Leon Foley and Reeves Jose Newsom.

The Secretary also announced that the Board of Government, under authority conferred at the annual meeting, had appointed the following special committees for the ensuing year.

On the Library. S. Everett Tinkham, Henry F. Bryant, Frederic I. Winslow.

On Publication. Charles W. Sherman, DeWitt C. Webb, George A. Carpenter.

On Membership. John E. Carty, chairman; Hugh Nawn, George E. Russell, Frank B. Sanborn, Robert Spurr Weston.

On Papers and Program. Lewis E. Moore, chairman; Walter W. Clifford, Samuel L. Conner, Arthur W. Dean, James B. Flaws, J. Arthur Garrod, Joseph H. Libbey, Howard B. Luther, Sturgis H. Thorndike, George C. Whipple, Henry B. Wood.

Social Activities. Edmund M. Blake, chairman; Charles H. Eglee, Frederic C. H. Eichorn, Clarence T. Fernald, Newton L. Hammond, Edwin H. Hayward, Laurence B. Manley, Edwin R. Olin, David S. Reynolds, Charles W. Sherman, Henry A. Symonds.

The Secretary announced the death of two members of the Society, Isaac Rich, who died March 11, 1915, and Benjamin G. Fogg, who died March 14, 1915. By vote the President was requested to appoint committees to prepare memoirs. The committees appointed are as follows: On memoir of Isaac Rich, Messrs. George T. Sampson, Frank B. Rowell and Theodore P. Perkins. On the memoir of Benjamin G. Fogg, Messrs. Leslie H. Allen and J. Arthur Garrod.

Past President Desmond FitzGerald, who had been appointed a committee to prepare a memoir of Robert Leland Read, submitted and read the memoir which he had prepared, and by vote it was accepted.

The President then introduced Mr. J. Albert Holmes, a former member of the Society, who read a paper entitled "Construction of the Earth Dam at Somerset, Vermont." The paper was illustrated by lantern slides. At the conclusion of the reading of the paper, Past President Frederic P. Stearns briefly discussed the paper and added some interesting facts drawn from his connection with the work. After passing a vote of thanks to Mr. Holmes for his kindness in presenting the paper, the Society adjourned.

S. E. TINKHAM, *Secretary.*

APPLICATIONS FOR MEMBERSHIP.

[May 7, 1915.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a

just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

COGHLAN, JOHN H., Lexington, Mass. (Age 27, b. Cambridge, Mass.) Graduate of Rindge Manual Training School, 1906; student in railroad engineering course at Boston Y. M. C. A. evening school, 1910. From 1906 to date, with the exception of three months, with the Boston Elevated Railway Co.; is now assistant engineer in M. of W. Dept. Refers to L. S. Cowles, C. T. Fernald, E. R. Kimball, Hugh Nawn, A. L. Plimpton and W. O. Wellington.

DE LA HAYE, ELIAS FRANCIS, JR., Roxbury, Mass. (Age 27, b. St. Owens, Jersey, Eng. Chan. Is.) Student for three years at Rensselaer Polytechnic Inst., civil engineering course. From Aug., 1905, to Jan., 1906, rodman with Smith & Brooks, civil engrs., Lowell, Mass.; from Jan., 1906, to Sept., 1908, rodman, inspector and transitman with N. Y., N. H. & H. R. R.; from Aug., 1911, to Aug., 1913, inspector and transitman with B. & M. R. R.; from Aug., 1913, to Jan., 1915, with C. A. Dodge & Co., Cambridge, as foreman on sewerage system at Billerica car shops and building of new Union Station at Pittsfield; from Jan., 1915, to date, architect on plans for hotel, Boston. Refers to S. P. Coffin, Louville Curtis, L. G. Morphy, F. B. Rowell, A. T. Safford and A. K. Williams.

KATZ, HARRY LEON, Malden, Mass. (Age 22, b. Frankfort-on-the-Main, Germany.) Graduate of Mechanic Arts High School, 1912; is now junior at Tufts College Engineering School. Assistant engineer with T. Stuart & Sons Co. during one summer; detailer with H. Cummings Machine Co. during one summer. Refers to H. P. Burden, S. L. Conner, E. H. Rockwell, F. B. Sanborn and R. C. Smith.

LEONARD, JOSEPH FRANCIS ALOYSIUS, Fall River, Mass. (Age 33, b. Fall River, Mass.) Educated in public and evening schools. From 1899 to 1902, assistant foreman, foreman and superintendent of concrete construction with Beattie & Cornell, general contractors; from 1902 to 1905, rodman and transitman with E. I. Marvell and W. T. Henry, civil and mechanical engineers; during 1906, chief-of-party with E. M. Corbett, civil engineer; during 1907, masonry inspector of reinforced concrete for Southern Railroad;

is now inspector of concrete for Barrows & Breed on Fall River intercepting drain. Refers to V. J. Gallene, E. I. Marvell, H. L. Robinson, G. S. Sawyer and A. L. Shaw.

PARKER, CHARLES FREDERICK, Woonsocket, R. I. (Age 47, b. Northfield, Vt.) Graduate of Norwich Univ., 1890, civil engineering course. From April to Aug., 1891, with Smith & Brooks, civil engrs., Lowell; from Aug., 1891, to Dec., 1895, with John W. Ellis, Woonsocket, R. I.; during winter of 1895-96, on resurvey of Conn. River division, B. & M. R. R.; from May, 1896, to Feb., 1897, in charge of drafting, masonry, construction and bridges on relocation of B., R. B. & L. R. R.; resident engineer on construction of 48 miles of electric road in southern Massachusetts in spring and summer of 1897; from April, 1898, to Jan., 1899, resident engineer on construction of masonry dam for City of New Britain, Conn.; from March, 1899, to April, 1901, with John W. Ellis & Son; successor to Mr. Ellis, in Woonsocket office, April, 1901, since which time has been in private practice as surveyor and general construction engineer; is one-half owner of Eastern Construction Co., general contractors. Refers to F. A. Caldwell, Willard Kent, F. H. Mills and Arnold Seagrave.

SILVERMAN, MAX, Dorchester, Mass. (Age 24, b. Boston, Mass.) Graduate of Mechanic Arts High School, 1909, and of Tufts College, 1914. During year 1910, draftsman for Boston Metal Ceiling Co.; from Sept., 1914, to date, with Boston Transit Commission. Refers to H. P. Burden, S. L. Conner, E. S. Davis, W. W. Davis and F. B. Sanborn.

LIST OF MEMBERS.

ADDITIONS.

ALLEN, JOHN E.....	11 Dean St., Worcester, Mass.
COREY, KENNETH T.....	102 Stratford Ave., Pittsfield, Mass.
FOLEY, ERNEST L.....	49 Adams Ave., West Newton, Mass.
GAMMAGE, ARTHUR L.....	151 Hancock St., Everett, Mass.
GARDNER, LEROY ERNEST.....	88 Morris St., Everett, Mass.
GREENE, FRANCIS I.....	5 Hoffman Place, Newport, R. I.
HAYES, JAMES, JR.....	472 Main St., Brockton, Mass.
M McNULTY, RICHARD J.....	23 Nottingham St., Dorchester, Mass.
MILLS, HIRAM F.....	66 Broadway, Lowell, Mass.
NEWSOM, REEVES J.....	50 Humphrey St., Swampscott, Mass.
ROY, JOSEPH E.....	11 Dean St., Worcester, Mass.
WESTON, ARTHUR D.....	141 State House, Boston, Mass.
WOOD, WILLIAM A.....	24 West St., Boston, Mass.

CHANGES OF ADDRESS.

ALLARD, THOMAS T.....	834 North 24th St., Philadelphia, Pa.
BRADBURY, ROYALL D.....	68 Devonshire St., Boston, Mass.
DRUMMOND, WILLIAM W.....	Care of Postmaster, Manila, P. I.

BOSTON SOCIETY OF CIVIL ENGINEERS.

EICHORN, FREDERIC C. H.....	672 Washington St., Brookline, Mass.
GERRISH, HERBERT T.....	10 Haskell St., Melrose, Mass.
GIBSON, FREDERICK M.....	1932 Beacon St., Boston, Mass.
LEE, EDWARD G.....	Room 40, Journal Bldg., Lewiston, Me.
LEWIS, GEORGE W.....	13 Stockton St., Dorchester, Mass.
MANN, JOHN L.....	2500 Municipal Bldg., New York, N. Y.
MORSE, CHARLES F.	57 S. Clinton St., Poughkeepsie, N. Y.
PARSONS, CHARLES S.....	806 City Hall Annex, Boston, Mass.
RUNELS, RALPH E.....	Box 1417, New York, N. Y.
SMITH, EDWARD R.....	1620 North 61st St., Philadelphia, Pa.
TOSI, JOSEPH A.	General Delivery, Station A, Worcester, Mass.

DEATHS.

FOGG, BENJAMIN G.....	Died March 14, 1915
FRENCH, ALEXIS H.	Died May 3, 1915
JENNEY, WALTER.	Died May 3, 1915

EMPLOYMENT BUREAU.

THE Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society room two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

MEN AVAILABLE.

305. Age 22. A student for two years at Dartmouth College and three years at Mass. Inst. of Technology. Has had some experience in surveying at Technology summer camp. Will accept any position along civil or sanitary engineering lines. Salary desired, \$60 per month.

306. Age 29. Received technical education at Boston Y. M. C. A. and from American School of Correspondence course. Experience includes six years with Stone & Webster Engrg. Corp'n, and three years with B. & A. R. R.; work has consisted chiefly of detailing and checking structural steel and concrete and general estimating. Desires position along these lines. Salary desired, \$25 per week.

307. Age 36. Graduate of Mechanic Arts High School Has had eighteen years' experience in engineering and construction work, including four years as transitman with Street Laying Out Dept., Boston; four years

with U. S. Engineers on fortification work; one year as resident engineer with Mass. Highway Comm.; one year as inspector of concrete on irrigation work in Montana; one year as superintendent of construction with H. Chase & Co., Seattle, Wash., and three years on survey work in Alaska. Desires position as transitman. Salary desired, \$85 per month.

308. Age 26. Graduate of Boston College High School; student in electrical engineering course for one and one-half years at Lowell Institute and is now student in civil engineering course with the American School of Correspondence. Has had no experience. Desires position as rodman. Salary desired, \$10 or \$12 per week.

309. Age 30. Received technical education at Thayer School of Civil Engineering, Dartmouth College. Has had seven and one-half years' experience, including two years of municipal work and about five and one-half years of building construction. Desires position on survey work or inspection of reinforced concrete, etc. Salary desired, \$120 per month.

LIBRARY NOTES.

INFORMATION WANTED.

We have recently had a call for a pamphlet, written by William Sooy Smith and published in Chicago in 1877, on the Detroit River Tunnel. We have not as yet been able to locate a copy of this pamphlet, and should be glad to hear from any member who can put us on the track of one.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

Annual Report on Statistics of Railways in United States for 1911-12.

Calcite Marble and Dolomite of Eastern Vermont. T. Nelson Dale.

Composition of Muds from Columbus Marsh, Nevada. W. B. Hicks.

Cretaceous-Eocene Contact in Atlantic and Gulf Coastal Plain. Lloyd William Stephenson.

History of Portion of Yampa River, Colorado, and Its Possible Bearing on That of Green River. E. T. Hancock.

Inorganic Constituents of Echinoderms. F. W. Clarke and W. C. Wheeler.

Lavas of Hawaii and Their Relations. Whitman Cross.

Mineral Resources of United States, 1913, 2 vols.: Part I, Metals; Part II, Non-metals.

National Standard Hose Couplings and Fittings for Public Fire Service.

Oil and Gas Development in North-Central Oklahoma. Robert H. Wood.

Stratigraphy of Montana Group. C. F. Bowen.

Seed Production of Western White Pine. Raphael Zon.

Results of Spirit Leveling in Maryland, 1896 to 1911, inclusive. R. B. Marshall.

Results of Spirit Leveling in Michigan, 1911 and 1913. R. B. Marshall.

Statistics of Express Companies in United States for 1912-13.

Statistics of Railways of United States, 1903-13.

Structure of Fort Smith-Poteau Gas Field, Arkansas-Oklahoma. Carl D. Smith.

Tests of Wood Preservatives. Howard F. Weiss and C. H. Teesdale.

Triangulation in Alabama and Mississippi. Walter F. Reynolds.

Water-Supply Papers 278, 312, 338, 340-F, 340-G, 341, 343, 348, 349, 350, 365, 367 and 368.

State Reports.

Connecticut. Annual Report of Public Utilities Commission for 1914.

Connecticut. Report of State Board of Health on Investigation of Pollution of Streams, 1914.

Massachusetts. Annual Report of Directors of Port of Boston for 1914.

Massachusetts. Supplementary Report of Directors of Port of Boston to General Court, March, 1915.

New Hampshire. Annual Registration Report for 1893.

New Hampshire. Annual Reports of Railroad Commissioners for 1909 and 1910.

New Hampshire. Reports of Public Service Commission, 1911-13.

New Hampshire. Annual Reports of State Board of Health for 1899-1900 and for 1903-12.

New Jersey. Annual Reports of Commissioner of Public Roads for 1909-13.

Municipal Reports.

Albany, N. Y. Annual Report of Bureau of Water for 1914.

Boston, Mass. Annual Report of Boston Transit Commission for 1913-14.

Duxbury, Mass. Annual Report of Water Commissioners, Fire and Water District, for 1914-15.

Haverhill, Mass. Annual Report of City Engineer for 1914.

New Bedford, Mass. Annual Report of Engineering Department for 1914.

New York, N. Y. Annual Report of Department of Water Supply, Gas and Electricity for 1913.

New York, N. Y. Street Paving and Maintenance in European Cities. Henry Welles Durham. Gift of author.

Rochester, N. Y. Annual Reports of Department of Engineering for 1910-13.

Taunton, Mass. Annual Report of Water Board for 1914.

Wellesley, Mass. Annual Reports of Water and Municipal Light Commissioners for 1914.

Worcester, Mass. Annual Report of Superintendent of Sewers for 1914.

Worcester, Mass. Annual Report of Water Commissioner for 1914.

Miscellaneous.

Canada, Department of Mines: Summary Report of Mines Branch for 1913; Preliminary Report on Mineral Production of Canada for 1914; Bituminous Sands of Northern Alberta, by S. C. Ellis; Non-Metallic Minerals used in Canadian Manufacturing Industries, by Howells Fréchette; Peat, Lignite and Coal, by B. F. Haanel.

Institution of Civil Engineers (London). Minutes of Proceedings, Vol. CXCVIII.

Spray Engineering Co.: Sprays for Cooling Condensing Water; Washing and Cooling Air for Steam Turbine Generators.

Tables Annuelles de Constantes et Données Numériques, 2 vols.: Données Numériques de l'Électricité, Magnétisme et Electrochimie, by P. Dutoit and others; Art de l'Ingénieur et Métallurgie, by S. L. Archbutt and others. Gift of International Commission on Annual Tables of Constants.

Where and Why Public Ownership Has Failed. Yves Guyot.

LIBRARY COMMITTEE.

NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before 1st of each month.)

United States Government. — NAVY DEPARTMENT. — *Navy Yard, Boston.* — Construction of shipbuilding ways. Erection of shipbuilding cranes.

Commonwealth of Massachusetts. — METROPOLITAN WATER AND SEWERAGE BOARD. — *Water Works.*

Bellevue Reservoir. — Work of painting the new steel tank on Bellevue Hill, West Roxbury, which is cleaned with a sand-blast before painting, is in progress. The tank is 100 ft. in diameter and about 45 ft. in height.

A contract for the construction of a masonry tower around the steel tank has been made with the John Cashman & Sons Co. of Boston, and work under the contract should be in progress at an early date.

Pipe Lines. — Work on the 24-in. cast-iron water main in Adams St., Milton, has been resumed under the contract with J. J. Evans of Lawrence.

A large portion of the 60-in. cast-iron water pipes which are to be used in extending the Weston Aqueduct Supply Mains in Commonwealth Ave., Newton, from Prince St. to the Charles River, has been received at the pipe yard and contracts are being made for laying them.

Sewerage Works. — Work is in progress on the relief outfall sewer at Nut Island and on surveys for the high level sewer to Wellesley. An extension of the outfall sewer at Deer Island is contemplated.

METROPOLITAN PARK COMMISSION. — The following work is in progress:

Charles River Reservation. — Plans and specifications for construction of a three-arch masonry bridge over the Charles River at North Beacon St., Boston and Watertown.

Furnace Brook Parkway. — Construction of parkway extension from Quincy Shore Reservation to Hancock St., Quincy. John Cashman & Sons Co., contractors.

Middlesex Fells Parkway. — Rebuilding the northerly half of Wellington Bridge with reinforced concrete girder construction. Coleman Brothers, contractors.

Mystic Valley Parkway. — Constructing parkway from Cradock Bridge to Mystic Ave. Coleman Brothers, contractors.

General. — General repairs to roads and treatments with bituminous binders.

DIRECTORS OF THE PORT OF BOSTON. — *Bulkheads.* — The wooden bulkheads adjoining the site of the proposed dry dock at the South Boston Flats are practically completed, making a total length of 10 305 lin. ft., of which 7 277.4 lin. ft. is composed of oak piles and sheeting 4 in. thick, and the remainder is of yellow pine piles with sheeting 6 in. thick.

Dredging. — The dredging of the Reserved Channel at South Boston east of the temporary entrance by the suction dredge *Tampa* has continued, making 30 ft. at mean low water in a channel 300 ft. wide. It is about 75 per cent. completed. The dredging of the Reserved Channel in South Boston between L Street Bridge and the temporary entrance is being done by J. P. O'Riorden's dredge *No. 8*, and is about 90 per cent. completed. Dredging is in progress at the site of Commonwealth Pier 1, East Boston, by the Bay State Dredging Company, making 40 ft. at mean low water.

Timber Breakwater. — The work on the timber breakwater east of Commonwealth Pier No. 6 is about 82 per cent. completed.

Boston Transit Commission. — *Dorchester Tunnel.* — The Dorchester Tunnel is completed from its connection with the Beacon Hill Tunnel at Tremont St. to the westerly side of Dewey Sq. Train service was begun between Park St. and the Washington station on April 4, 1915.

Section D includes a station under Dewey Sq. and about 450 ft. of tunnel under Summer St., east of the station. Work is now in progress on both station and tunnel. The Hugh Nawn Contracting Co. is the contractor.

Section E includes two single-track circular tunnels which will extend from near the junction of Summer St. and Dorchester Ave. under the Fort Point Channel and private property to a point near Dorchester Ave. between West First and West Second Sts., South Boston. The tunnels will be driven by means of two shields and with compressed air. The shields are now being erected and equipped in the bottom of the shaft at West First St. They are about 24 ft. 5 ins. in diameter, $12\frac{1}{2}$ ft. long and weigh over 80 tons each, not including the hydraulic jacks. The shields were made under subcontract by the Boston Bridge Works. P. McGovern & Co. are the contractors for the construction of the section.

Section H is located in Dorchester Ave. between Old Colony Ave. and Woodward St., and is about 2 200 ft. long. The structure is to be mainly of reinforced concrete, and consists of a single-span double-track tunnel to be built by the cut-and-cover method. The work also includes a pump well, an emergency exit, and sewer changes. Excavation between Middle and Woodward Sts. is under way. The T. A. Gillespie Co. is the contractor.

Enlargement of Park Street Station. — At the junction of Park and Tremont Sts., just north of the station proper, the triangular core of earth has been removed and the work of placing the new steel columns and roof beams and cutting out some of the old concrete walls and roof is now in progress.

This work is being done partly to increase the clearance between the tracks of the double loop in order to enable large semi-convertible cars to pass around the loop on both tracks at the same time.

East Boston Tunnel Extension. — The tunnel extension has been completed with the exception of the interior finish of terrazzo, white cement plaster, etc., of the two stations respectively located under and near the present Scollay Sq. station and under Bowdoin Sq., and also with the exception of their stairways, entrances and exits. Work on the interior finish and on the stairways is in progress. Lowering the grade of the East Boston Tunnel in Court St. between Washington St. and Cornhill is nearly completed. Near Young's Hotel the invert is being removed and the earth underneath excavated to the new grade.

City of Boston. — PUBLIC WORKS DEPARTMENT, HIGHWAY DIVISION, PAVING SERVICE. — Work is in progress on the following streets :

Sanger Street,	from E. Seventh St. to E. Eighth St.	Bituminous macadam.
Winfield Street,	from E. Seventh St. to E. Eighth St.	Bituminous macadam.
St. Andrew Road,	from Bayswater St. to Washburn Ave.	Bituminous macadam.
Frankfort Street,	from Bennington St. to Neptune Rd.	Bituminous macadam.
Braintree Street,	from Franklin St. to Everett St.	Hassam block.
Albano Street,	from Washington St. to Amherst St.	Bituminous macadam.
Barbara Street,	from S. Huntington Ave. to Centre St.	Bituminous macadam.
Jewett Street,	from Neponset Ave. to Mt. Hope St.	Bituminous macadam.
Philbrick Street,	from Neponset Ave. to Jewett St.	Bituminous macadam.
Rosecliff Street,	from Washington St. to Kittredge St.	Bituminous macadam.
Kittredge Street,	from Rosecliff St. to Metropolitan Ave.	Bituminous macadam.
Spring Street,	from Gardner St. to Webster St.	Bituminous macadam.
Temple Street,	from Spring St. to Ivory St.	Excavating, grading.
Hillcrest Street,	from Elgin St. to Temple St.	Excavating, grading.
Seaver Street,	from Blue Hill Ave. to Walnut Ave.	Excavating, grading.
Deering Road,	from Blue Hill Ave. to Harvard St.	Bituminous macadam.
Intervale Street,	from Columbia Road to Normandy St.	Bituminous macadam.
So. Sydney Street,	from Savin Hill Ave. to Bay St.	Bituminous macadam.
Fabyan Street,	from Blue Hill Ave. to Harvard St.	Asphalt pavement.
Dempster Street,	from Ruggles St. to Halleck St.	Hassam block.
Chestnut Street,	from Brimmer St. to Charles River (Ave.).	Bituminous macadam.
Lockwood Street,	from Metropolitan Ave. to Huntington Ave.	Bituminous macadam.

PUBLIC WORKS DEPARTMENT, SEWER AND WATER DIVISION, SEWER SERVICE. — The following work is in progress:

Dent Street Brook conduit, West Roxbury. — In private land, parallel with Dent St., near Pleasant St.

Faneuil Valley Brook conduit. — Faneuil and Oakland Sts., Brighton.

Orleans Street sewer outlet. — In tunnel under tracks of B. & A. R. R. near Bremen and Marion sts., East Boston.

Dorchester Brook conduit and sanitary sewer. — Work now in Judson St., between West Cottage and Brookford Sts.

Union Park Street Pumping Station, South End. — Completed. Machinery being installed.

Kilby Street, Central and Milk Streets, City Proper. — Old wooden sewers being removed and new ones being built.

The Fore River Shipbuilding Co., Quincy, Mass., has the following work in progress:

U. S. Battleship *Nevada*.

Nine U. S. submarine boats.

U. S. Torpedo Boat Destroyers *Cushing*, *Tucker* and Nos. 63 and 64.

Two oil-tank steamers.

One molasses tanker.

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

GROUND WATER SUPPLIES.

BY WILLIAM S. JOHNSON, MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

(Presented February 17, 1915.)

A FEW years ago the prophecy that the time was coming when no unpurified surface water supplies would be used for drinking purposes sounded very rash, but our education in these matters has been so rapid that now, in this part of the world at least, it is almost an accepted fact that some form of purification should be adopted for even the so-called unpolluted surface supplies.

It is not long since a considerable portion of our population, even in Massachusetts, which has always been in the lead in sanitary matters, was contentedly drinking diluted sewage. Now there are few places, and certainly none in Massachusetts, where water which receives the direct discharge of sewage is used for public purposes without purification. We are, however, still drinking water coming from populated watersheds and receiving indirectly the wastes from the entire population as well as the surface wash from streets and fertilized fields, protected only by the natural purification which takes place before the water reaches the consumer. This natural purification would be a perfectly satisfactory method if it could be controlled so as to make its action certain, but some of our worst

NOTE. Discussion of this paper is invited, to be received by Edward C. Sherman, Editor, 6 Beacon Street, Boston, before August 15, 1915, for publication in a subsequent number of the JOURNAL.

epidemics, like that at New Haven a few years ago, have been caused by the interruption of the natural purification.

Long storage is the most efficient of the natural methods of purifying surface waters, and this method is being developed by many of our large cities. The purity of the supply of the Metropolitan District is largely dependent on long storage. The difficulty is that we are not always certain that we are obtaining long storage, for there is the possibility of local pollution near the intake. The control of the watersheds and the removal of all population from them is, of course, a great aid in securing safe water, especially if the public is excluded from the immediate vicinity of the sources of supply. To supply the population of Massachusetts, however, would require, with a reasonable development by means of storage, a watershed of about one tenth of the total area of the state, and the condemnation of this area is manifestly out of the question.

The demands of the fastidious public have not stopped at freedom from disease-producing pollution, but there is an increasing demand for clean as well as safe water. The public is no longer satisfied to drink dirty or discolored water, even though free from disease germs. It certainly is not appetizing to think of drinking water in which cattle have waded and fishermen have expectorated, or which has flowed over cultivated fields. Neither is it agreeable to drink a highly colored water which has received its color from the organic matter in swamps, and this is what we have to do in the case of many of our surface supplies.

Storage, with the certainty that all of the water will be held for a sufficient time, is a satisfactory remedy for these conditions, and the one upon which we must depend in many cases for some time to come. The only other feasible remedy is filtration.

By filtration, almost any surface water can be made of satisfactory quality for drinking purposes, but, unfortunately, artificial filtration is expensive, and, unless the processes are constantly under the supervision of a trained attendant, reliable results cannot be obtained. In the smaller places it is practically impossible, on account of the expense, to maintain

a proper filtration plant; or, rather, it appears impossible to the majority of the water takers and taxpayers. Fortunately, however, there is available for most of the smaller places, and even for some of the larger places, a natural filtration, cheap and effective and not dependent on the intelligence or faithfulness of any hired attendant.

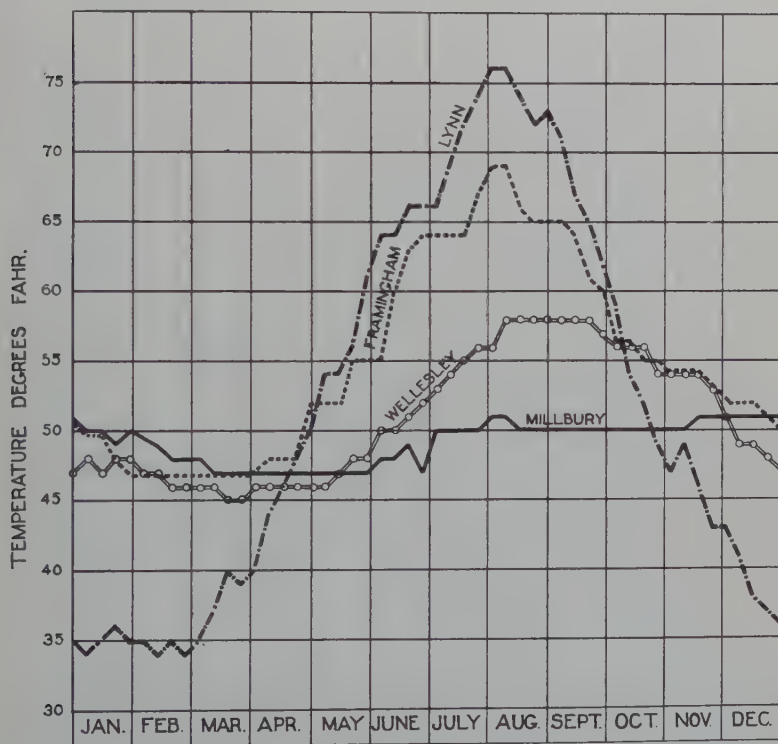


FIG. I. SEASONAL FLUCTUATIONS IN TEMPERATURE OF GROUND AND SURFACE WATERS.

A considerable portion of the rain which falls upon the surface of the ground enters the soil and flows through it to the most available outlet, which may be a neighboring stream or some distant water course. This water, filtered usually under the most favorable conditions for ideal purification, has all of

the qualities requisite for a perfect water supply, provided certain objectionable qualities which will be referred to later are absent. Good ground waters are practically certain to be at all times cold, colorless, tasteless, odorless and free from dangerous pollution. This is more than can be said of the best surface supply, for such a supply is certain to be warm in summer and to have occasional tastes and odors, and there is always the danger of local pollution.

The temperature of the water is an important factor which is frequently overlooked. Ground waters which are not derived to any considerable extent from a nearby surface source have an almost uniform temperature throughout the year of about 50 degrees. This is sufficiently cold to make the water palatable without ice. Surface waters, on the other hand, reach a temperature of over 70 degrees in summer, although if the water remains long in the pipes it becomes somewhat cooler.

Figure 1 shows the seasonal fluctuations in temperature in typical ground water and surface water supplies. The curve marked "Lynn" is the temperature curve of a pond used for domestic purposes; that marked "Framingham," a filter gallery located close to the shore of a pond and receiving a large proportion of its water by filtration from the pond; "Wellesley," a filter gallery which receives some water by filtration from a river but also a considerable quantity of water from the ground on its way toward the river; "Millbury," a supply which gets little or no water from any adjacent surface source.

The use of ground waters for water-supply purposes is nothing new. They have always been used for domestic purposes, but their general use in connection with public supplies is of comparatively recent origin. At the present time, of the 208 cities and towns in Massachusetts which are supplied with water from public works, about 100 are supplied either wholly or in part from ground water sources. In the main, it is the smaller places which are so supplied; but the city of Lowell, the fourth city in Massachusetts, is supplied entirely from ground water sources, as are the cities of Newton and Waltham, while in other parts of the country very large supplies have been developed. In Germany ground waters are very generally

used, a large proportion of the municipalities being supplied with water derived from such sources.

When ground water supplies first began to come into general use our knowledge in regard to them was very meager. We were dependent upon the expert with the witch-hazel stick or upon the advice of the well driver, and usually the opinion of one was just as good as that of the other. The records of failures of ground water supplies have been numerous, but in Massachusetts they are nearly all those supplies which were installed before the investigations of the State Board of Health were begun. This work, started about twenty-five years ago, has been brought to an exact science under the direction of Mr. X. H. Goodnough, chief engineer of the Board, so that it is possible to predict almost with certainty the quantity and quality of the water which can be obtained from the ground; and the application of this knowledge has prevented many costly mistakes by municipalities introducing water supplies.

It is difficult for the average layman, and even for many engineers, to realize that the laws of nature operate in just the same manner on water beneath the surface of the ground as where the water can be seen. People like to believe that the unseen must be supernatural. This characteristic of human nature has been the chief source of income of many of the well drivers in the past and is the reason why the man with the witch-hazel stick has flourished.

There is another expert, however, who perhaps has done as much harm as the man with the well-driving apparatus or the witch-hazel stick, and this is the theorist who figures out the coefficient of friction in the soil and the velocity and hydraulic gradient of the ground water and determines with nicety just how much water can be obtained from a given source. For such soils as we have in New England, at least, such work is a waste of time and absolutely worthless. The soil varies so in every foot that to obtain results which are accurate to any reasonable degree would require investigation of the soil by means of test wells much more extensive and expensive than would be required to determine first hand, by actual experiment and without any figuring, what the ground will yield.

Ground water is, strictly speaking, any water which is taken from or flows from the ground. It is derived chiefly from that portion of the rainfall which is absorbed by the soil, but also to some extent from the surface water sources, water from which finds its way into the surrounding ground. Ground water sources may be roughly divided into springs, deep wells (sometimes called artesian wells), shallow wells and filter galleries.

With the deep wells we have very little concern. It is sufficient to say that there are very few deep wells in New England which supply a sufficient quantity of good water to be of any assistance in connection with a public water supply system. In Massachusetts, probably hundreds of thousands of dollars have been spent in driving deep wells with a view to securing public water supplies, but there is not one really successful well to show for all of this money.

Springs are ground waters which come naturally to the surface of the ground, and these generally furnish an excellent quality of water. There are few problems connected with the development of such a supply, as the quantity of water which the spring will yield can be seen and measured and there is no reason why its quality should change from time to time. If, however, the spring is developed by putting in a well or wells, the conditions may be very much changed and the supply would then be treated in the same manner as one which is secured from shallow wells.

Shallow wells are those usually not more than 30 or 40 ft. in depth, obtaining most of the supply from rain water which has entered the ground in the immediate vicinity, although they are frequently supplemented by water which is obtained from some nearby stream. To obtain a satisfactory supply from shallow wells it is necessary that there should be an area with pervious soil near the surface which will absorb a considerable portion of the rain which falls upon it, and there should also be a stratum of pervious soil at a reasonable depth which will collect this water. If this deeper pervious stratum can be penetrated by wells, a supply of water will be secured.

Filter galleries or filter basins are those which derive a considerable portion of their supply by filtration from some

adjacent surface source, and they are usually not far beneath the surface of the ground. The proportion of the water obtained from the surface source varies greatly, in some cases being nearly the entire supply. In a few cases the yield of wells or filter basins has been increased by discharging water on the surface of the ground in the vicinity, thus creating what might be termed an artificial ground water. This was done recently in Greenfield, where a well was sunk in a small sandy area near Green River and a dam constructed across the river to divert river water to the sandy land around the well.

The first requirement in seeking a ground water supply is that there should be a watershed of sufficient area to yield the required quantity of water, or that there should be a surface source which can be depended on to supplement the supply. The superficial watershed is not in all cases the watershed which will be tributary to the source after the ground water level is lowered. At Marblehead a well which did not appear from surface indications capable of yielding more than about 200 000 gals. per day has been yielding more than 500 000 gals. per day continuously for many years, and wells far outside of the apparent watershed have been drained.

What the yield of a given watershed will be depends chiefly on the character of the surface soil. There are cases where practically all of the rainfall except that which has evaporated finds its way into the soil, while there are other cases where practically none of the rainfall will enter the ground but will all flow over the surface to the nearest stream. The infiltration from a pond or stream is also exceedingly uncertain. There may be a stratum of impervious material which will almost absolutely prevent the direct infiltration from a surface source, and there are numerous cases where the water is drawn from the ground on the opposite side of a river from the collecting works, the ground water level on both sides of the stream being much lower than the surface of the stream. Another case which frequently arises is that of a deposit of porous material from which water can be drawn freely for a time, but long-continued pumping will exhaust the supply, as the porous material simply forms a reservoir and the flow into the reservoir is small.

Cases have been found where one well yields as much water as many wells driven in the vicinity. Such a case has recently come to my attention in New York, where ten wells were driven, each of which when tested alone gave a good yield. These wells were connected up and a pumping plant installed of sufficient capacity to pump as much water as was expected from the combined wells, but the result was that no more water was obtained from the group of wells than was obtained from the first test well driven.

While experience in these matters will give very much assistance, the only certain way to determine how much water may be obtained continuously at any particular place is by means of tests. The pumping test, as it has been developed by the engineers of the State Board of Health, consists in driving tubular wells and testing each individually until enough good wells are found to yield water at a rate at least as great as will be required for the completed works. These wells are then connected up with a pump, and water is drawn from them continuously for a period, the length of which depends upon the results which are obtained. Observation or witness wells are driven around the area from which the water is being drawn, and a record is kept of the height of water in the ground at frequent intervals. After the pumps are stopped, the observation of the height of water in the wells is continued until the original level is practically reached or the level of the water becomes nearly stationary.

With the results of such a test it is possible, allowing for the difference in yield in a dry season and a wet season, to predict with a considerable degree of certainty the quantity of water which can be obtained from the source.

The necessary duration of a pumping test is generally from one week to two weeks, although there are times when a test of a week is unnecessary and again there are times when a much longer test is desirable. The test usually ceases when the water in the ground reaches a state of equilibrium, or if, after pumping for one or two weeks, the ground water level still continues to go down at a rapid rate.

One of the serious disadvantages in selecting a ground water supply is that expensive tests must be made before it can be

located, whereas with a surface water supply the source can be selected before going to any considerable expense. When a water supply is being considered in a town the money for tests is obtained with difficulty and it is next to impossible to convince a committee that a thousand dollars put into a test will be money well expended, admitting as you must that as a result of the expenditure there may be nothing to show except failure.

TABLE I.

RESULTS OF ANALYSES OF SAMPLES OF WATER COLLECTED FROM THE
WELLS DURING PUMPING TEST AT DUXBURY, MASS.
(PARTS IN 100 000.)

Date of Collection.	APPEARANCE.			Residue on Evaporation.	AMMONIA.		Chlorine.	NITROGEN AS		Hardness.	Iron.
	Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.		
1914											
June 1	None	Very slight	0	5.00	.0000	.0008	.68	.0300	.0000	0.8	.007
" 2	None	None	0	4.80	.0000	.0010	.61	.0300	.0000	0.5	.003
" 3	None	Very slight	0	3.50	.0000	.0010	.58	.0280	.0000	0.5	.007
" 4	None	None	0	3.90	.0002	.0008	.54	.0220	.0000	0.5	.001
" 5	None	None	0	3.40	.0006	.0014	.55	.0220	.0000	0.5	.001
" 6	None	None	0	2.90	.0000	.0006	.59	.0180	.0000	0.5	.001
" 7	None	None	0	3.30	.0004	.0018	.63	.0180	.0000	0.5	.001
" 8	None	None	0	3.70	.0004	.0010	.64	.0280	.0000	0.5	.001
" 9	None	None	0	3.50	.0006	.0016	.66	.0040	.0000	0.2	.000
" 9	None	None	0	4.20	.0000	.0014	.66	.0200	.0000	0.2	.000
" 10	None	None	0	2.90	.0002	.0012	.69	.0220	.0000	0.2	.000

The preliminary investigations for a ground water supply cost from five hundred dollars upwards. Many times the first location tested proves satisfactory and the cost is comparatively small. Such was the case recently at Duxbury, where the first wells driven proved absolutely satisfactory. On the other hand, in cases like Bedford and Norton, very extensive tests were required before a suitable supply was secured. The cheapest complete test of which I have any record was at Ashland, where the driving of the wells and the conducting of a pumping test was done for about \$225. This was possible, however, only by the use

of a borrowed pump and the services of citizens who volunteered to operate the pump during the test without expense to the town, such was their enthusiasm in getting a water supply. The cost of the test, of course, varies with the size of the plant required, but for a test of from 200 000 to 400 000 gallons per day the wells and the connections will cost in the vicinity of \$500, and conducting the pumping test will cost about \$30 per day of twenty-four hours, making the total cost of a pumping test of a duration of ten days a little less than \$1 000. The wells used in the test can generally be made a part of the permanent works if the test is successful.

The quality of a ground water supply is certain to be good if it does not receive drainage from a considerable population located near the source of supply or if it is not hard and does not contain iron or manganese. These are the only troubles which are at all likely to occur in a ground water supply in this vicinity.

The effect of the population on the territory which feeds the well will not be serious unless the population is large or is located close to the well. The effect of the discharge of sewage into the ground through cesspools will be greater than if the wastes are discharged into vaults or on the surface of the ground, as there is better opportunity for purification when wastes are discharged on the surface. Under favorable conditions the soil will thoroughly purify the wastes from a large population; that is, the organic matter will be changed over to inorganic, and there will be no disease germs in the water. There are, however, certain objectionable qualities in water which has been previously polluted by sewage which should be avoided.

The hardness is of comparatively little consequence in the easterly section of New England, where water is drawn from shallow ground water sources. In deep wells and in certain sections where there is limestone, the hardness may be sufficient to make the water unfit for domestic purposes. The hardness will not change materially with continued pumping and can be determined satisfactorily from a single sample.

The great trouble with ground water supplies is the possibility of the presence of iron or manganese. Without going into a discussion of the chemistry of the subject, it may be said that

iron in ground waters is due to the passage of the water through organic matter which uses up the dissolved oxygen which the water may contain and leaves it with carbonic acid. All sand contains more or less iron, and water containing carbonic acid dissolves the iron from the sand very readily. This, in brief, is the cause of iron in ground waters. As the water subsequently passes through sand which contains free oxygen, the iron will be precipitated and the water will eventually become again practically free from iron.

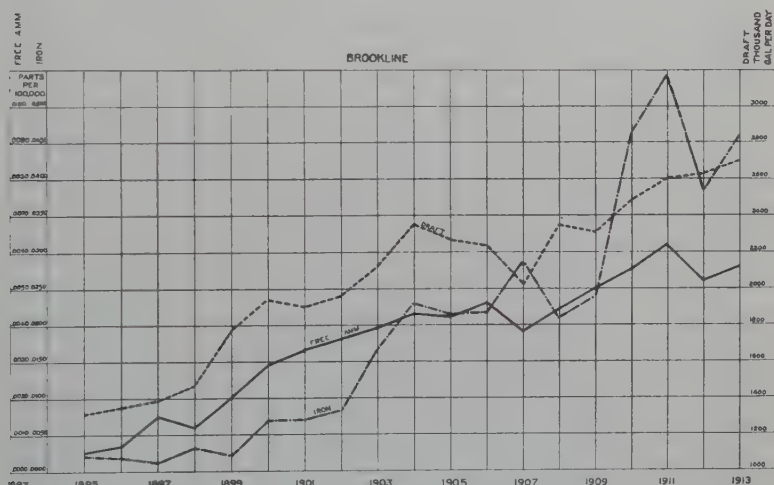


FIG. 2. PROGRESSIVE CHANGES IN QUALITY OF A GROUND WATER.

A source which may furnish excellent water when the draft is small may yield quite different water when a large quantity is drawn from it continuously. This change in the character of the water is due both to the extension of the area from which the water is drawn and to the increased rate at which the water flows to the wells when the ground water level is lowered. The deterioration in the character of the water has been very marked in many of the sources of public supply, especially those which were put in before the modern methods of determining the probable future quality of water were evolved. The deterioration

due to continued pumping is manifest chiefly in the increase in iron or manganese.

The accompanying diagram, Fig. 2, shows the changes in the quality of the water of a typical ground water source which has been in use for a considerable period of years, together with the draft from the source. In some sources which are located near a deposit of organic matter there has been a decided deterioration, while in others the quality has remained good even with a greatly increased draft.

In Middleborough and Lowell the deterioration in the water has been so great that filters have been installed for the purpose of removing the iron, and in Brookline filters will probably be built within a short time.

This deterioration in the water is not universal, for there are a great number of supplies which have continued to give excellent water for a very long time, and this is especially the case where the sources have been selected after a thorough test.

Since the troubles which occur in ground waters are chiefly those which come from the passage of water through organic matter, it is evident that it is desirable to locate the collecting works as far as possible from any such organic deposits. For this reason wells should not be located where they will receive water which passes through deep deposits of peat, and they should not be located close to a stream or pond the bed of which is covered with mud. The distance from such deposits at which it is safe to put the works cannot be foretold, as the purification of the water in passing through the soil depends upon the character of the water, the character of the filtering material and the rapidity with which it passes through this filtering material.

It is found to be generally safe if the well is located at least one hundred feet from the shore of a surface source or from a deposit of peat. Cases have frequently occurred where, by moving the collecting works a distance of a few hundred feet, water of very much better quality has been secured.

One of the most important functions of the pumping test is to determine the probable future quality of the water. It is possible to determine what the quality of the water is in its

natural state as it flows through the ground by means of samples collected from test wells. This is the quality of the water which will be secured if the water should come to the surface of the ground in the form of springs. When, however, the water is pumped from the ground, the conditions are changed very materially. The surface of the ground water is lowered, which tends to draw toward the wells water from a different area from that which would flow to this point naturally. If there is a body of water in the vicinity, the lowering of the ground water level will tend to draw water from this surface source, and the rate of infiltration will increase as the ground water level is lowered, thus producing entirely different conditions from those which naturally exist. This difference in conditions when water is pumped has been responsible for many of the troubles which have occurred with ground water supplies.

While the pumping test is in operation, samples for chemical analysis are collected at least once each twenty-four hours, and so delicate is the test that it is possible to foretell whether there is likely to be trouble with the water in the future. An increase in the iron or in the free ammonia, as the test progresses, is a sure indication of future trouble, although the trouble may not be serious for several years.

In certain soils it is almost impossible to get clear samples when pumping with a hand pump attached to a well, and the turbidity cannot be entirely removed by filtration in the laboratory. Turbid samples generally show iron, and this iron may not be present in the water itself and would disappear as soon as the water came perfectly clear. Cases have been known where this turbidity has remained for several days after water has been drawn continuously from the wells, and the iron content has been high; but eventually water free from iron has been obtained.

As to the relative merits of driven wells, dug wells or filter galleries, there is no question but that the dug well is the most satisfactory, provided the conditions are favorable and if the expense is not too large. Where water is obtained from some neighboring water source and the depth of porous material is small, a filter gallery parallel to the shore of the surface source may be desirable. Where the water-bearing soil is at some

considerable depth it is almost invariably much cheaper to obtain water by means of tubular wells.

Between these two extremes the best method to adopt must be determined by local considerations. One of the advantages of the dug well is that there is a large body of water in store from which to draw while the pumps are being run, and when this is exhausted the well has the time until the pumps are next operated to recover. This means that pumps of larger capacity can be used than with the driven well plant. Furthermore, under these conditions the average suction is likely to be less, as in the case of driven wells the ground water level at the wells goes down quickly when the pumps are started. Perhaps the chief advantage, however, of the large well is the avoidance of troubles from sand and air which are likely to occur in any driven well plant.

Another type of well, used considerably abroad, and to some extent in this country, is a large pipe 6 ins. or 8 ins. in diameter, which is driven into the ground and water is drawn from this well by means of a smaller pipe inserted in the larger one. This avoids the troubles with air and sand to a very large extent, but is, of course, somewhat more expensive.

A modification of this type has been used with very good success in two or three installations in this vicinity, by the Hanscom Construction Company. Sections of cement pipe or of tile pipe 2 ft. in diameter are sunk by dredging on the inside of the pipes to the required depth. Water is drawn from these by means of small suction pipes connected up as in the case of tubular wells. These wells are comparatively inexpensive and have proved very successful, avoiding most of the troubles which occur with the ordinary driven well.

The cost of a system for collecting ground water varies greatly with the local conditions. The following tables give statistics in regard to the cost of dug wells and of recent installations of systems of tubular wells.

TABLE 2.
COST OF DUG WELLS.

Place.	Year Built.	Depth in Ft.	Diameter in Ft.	Cost.
Bedford.....	1909	21.0	20.0	\$3 981
Avon.....	1895	22.0	20.0	3 317
Canton.....	1889	29.0	40.0	8 555
Cohasset.....	1909	33.67	25.0	3 500
Greenfield.....	1913	31.0	40.0	7 850
Henniker, N. H.....	1914	25.15	20.0	2 141
Manchester.....	1892	29.0	32.0	10 476
Marblehead.....	1912	31.0	25.0	6 100
Middleborough.....		22.0	26.0	4 964
Monson.....	1895	23.0	72.0	6 803
Needham.....	1890	24.0	22.0	4 615
Waltham.....		18.0	40.5	8 940
Ware.....		23.0	25.5	4 725
Webster.....		30.0	25.0	13 344
West Warren.....	1913	18.0	20.0	3 800
Winchendon.....	1911	35.0	40.0	7 815

TABLE 3.
COST OF TUBULAR WELLS.

Place.	No. and Size.	Depth in Ft.	Cost of Wells.	Cost per Well.	Cost, including Suction to Pumping Station.
Ashland	12 — 2½ in.	25-32	\$1 267	\$105.50	\$1 460
East Brookfield	9 — 2½ in.	20.7 av.	604	67.20	....
East Douglas	9 — 2½ in.	....	....	....	629
Duxbury	22 — 2½ in.	27.8 av.	....	....	3 324
Littleton	10 — 2½ in.	22 av.	....	....	2 000
Merrimac	18 — 2½ in.	35 av.	....	....	3 100
North Chelmsford	20 — 2½ in.	30 av.	2 800	140.00	....
Oxford	15 — 2½ in.	24-28	....	....	800
Pepperell	34 — 2½ in.	19-28	2 704	79.50	3 200
Plainville	11 — 2½ in.	25-50	4 500	....	....
Uxbridge	16 — 2½ in.	26-35	1 800	112.50	....
Wrentham	9 — 2½ in.	29 av.	1 048	116.50	....
Wrentham State School	6 — 2½ in.	....	680	113.20	....
Fairhaven	30 — 2½ in.	22½ av.	2 040	68.00	5 645
Wareham	12 — 2½ in.	39 av.	1 160	97.00	....

The construction of tubular wells and the method of making connections with the suction pipe are of the greatest importance, as the leakage of a small quantity of air will cause endless trouble; and it is also desirable that it should be possible to cut out any particular well from the system.

The usual size of driven wells in this part of the country is $2\frac{1}{2}$ ins. The adoption of this size is simply the result of experience, as it is found that this is about as large a pipe as can well be driven under ordinary conditions, and it is, of course, desirable to have the pipe as large as is feasible. For the well,



FIG. 3. DRIVING PIPE BY TRIPOD.

an extra heavy wrought-iron pipe should be used, as in the process of driving the pipe receives very hard treatment and it requires a heavy pipe to stand the strain. The pipes are driven with open ends except in the case of very fine sand, when strainers have to be resorted to. The bottom length of pipe is perforated with a large number of small holes about $\frac{1}{4}$ in. in diameter for a distance of perhaps two feet from the end of the pipe.

The two methods of driving the pipes most commonly in vogue are shown in the accompanying views. The use of the

tripod is simpler, but the platform has the advantage of carrying the weight of the men upon the pipe, which assists materially in sending the pipe down with each blow. It would seem that raising the weight by a rope would be much easier for the men than to stoop down and lift the weight, as is necessary with the

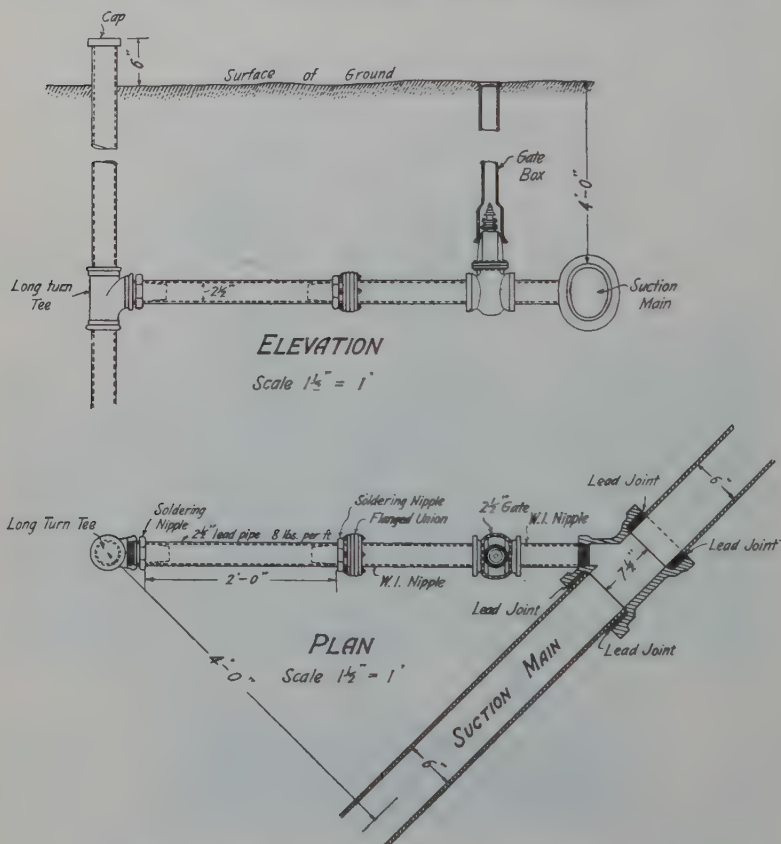


FIG. 4. DRIVING PIPE WITH PLATFORM.

platform. Men, however, seem, if anything, to prefer this method to the tripod method.

After the pipe is driven and washed out, it is cut off at the level at which the suction is to be placed. A long-turn *T* is put on and then the pipe is continued up to somewhat above the

surface of the ground, the object of the extension to the surface being to provide access to the well for cleaning out, as sand is likely to work into the pipe. The well is then connected to the suction with $2\frac{1}{2}$ -in. pipe and a lead gooseneck, each connection



being provided with a gate so that it can be shut off in case it gives trouble. The object of the piece of lead is to give flexibility to the connection and prevent danger of leakage.

There is always a certain amount of sand which finds its way into the water, and to prevent this from getting into the pumps

a sand chamber is put on the suction. This sand chamber is simply a large chamber in which the velocity of the water is sufficiently checked to permit the sand to drop out of the water.

Air is one of the great troubles in a driven well system, and in some cases pumps are installed which operate automatically to remove the air either from the top of the sand chamber or from a special air chamber constructed for the purpose.

Ground water, as has been said, is likely to be of satisfactory quality if it does not contain iron or manganese and if it is not hard. If the water is hard, it is probably not feasible to use it for domestic purposes. If it contains iron or manganese, it is perfectly possible to remove these substances and make the water of satisfactory quality. The filtration of a ground water containing iron is likely to be a much more simple and less expensive process than the filtration of surface waters, although the iron occurs in so many forms or in combination with so many other substances that it is impossible to tell in advance how simple or how difficult the process of removal is likely to be. In the case of Marblehead, for example, the iron is very readily oxidized and precipitated by simple aëration, and then the iron can be readily strained out by passing it through sand filters at a rapid rate. At Reading, on the other hand, the iron occurs in connection with organic matter, which makes it very difficult to remove, and it must be treated chemically. In Germany, where ground water supplies are very largely used, a large majority of them are purified on account of the presence of manganese or iron.

The failure to properly purify a polluted surface water is a serious thing, but the failure of plant filtering a ground water does not mean a possible injury to the users of the water, for the iron or manganese is harmless, and the worst that can happen is to serve water which causes rust spots in the laundry and has an objectionable appearance and taste.

Ground water supplies are usually found in locations where it is necessary to pump the water, and the pumping plant is an essential part of the development of a ground water supply. There are a few cases, like Monson, West Warren and Deerfield, where good ground water supplies are obtained by gravity; but such cases are very rare.

The development of the oil engine in connection with public water supplies is responsible in a very large measure for the increase of ground water supplies in recent years. The cost of construction and operation of a steam pumping plant is so great as to discourage a small town from installing a supply where these are necessary. The oil engine, however, is so much cheaper in first cost, and the cost of maintaining it is so small, that it is more economical to put in a pumping system and pump water from some nearby ground water source than to go to any considerable distance for a gravity supply.

The following facts in regard to the cost of pumping plants may be of interest in this connection.

TABLE 4.

COST OF RECENT INSTALLATIONS OF PUMPING MACHINERY IN SMALL WATER-
WORKS SYSTEMS.

Town.	Population (1910).	Cost of Pumping Station.	Cost of Pumping Plant.
Ashland.....	1 682	\$1 935	\$4 358
Bedford.....	1 231	1 857	4 000
Deerfield.....	.....	350	475*
Dracut.....	3 461	1 730	1 783
Dudley.....	4 267	1 948	2 500
Duxbury.....	.....	6 181	.....
East Brookfield.....	.....	1 628	3 100
East Douglas.....	2 152	2 500	2 455
Henniker, N. H.....	.....	1 250	1 757*
Leicester (Cherry Valley and Roch- dale).....	.....	2 368	4 414
Littleton.....	1 229	3 100†	3 960
North Chelmsford.....	5 010	2 000	3 500
Pepperell.....	2 953	2 852	6 200
South Hadley (Fire District No. 2) ..	.....	2 700	6 875
Wareham.....	.....	2 133‡	5 642
West Groton.....	.....	500‡	1 163*
Wrentham.....	1 743	1 647‡	1 784*

There are in many small towns, ground waters which can be developed to supply a considerable quantity of water which

* Only one unit.

† Includes some grading.

‡ Without pumping machinery foundations.

are so located that the water can be obtained by gravity, although the yield of these sources may be insufficient to supply all the requirements of the town. These ground water supplies may oftentimes be developed economically to supply a portion of the water required, and a small pumping unit can be installed to supplement the supply when necessary. Such installations have been put in recently in the Deerfield Water District and in Henniker, N. H. The gravity supply in these places is sufficient to meet all the requirements during wet seasons, and an inexpensive pumping unit supplies the deficiencies during dry times. The saving to the town in such cases over the cost of installing either a complete gravity supply or a complete pumping supply is very considerable, especially during the first years of the operation of the plant.

Ground water when exposed to light deteriorates very rapidly on account of the growth of microscopical organisms, and, in order to keep a ground water supply satisfactorily, it is necessary to keep it from exposure to the light. Consequently covered reservoirs are absolutely essential. These reservoirs may be either standpipes or masonry structures, the latter being preferable on account of preserving the low temperature of the water.

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DISCUSSION OF THE ECONOMIC DEPTH OF
TRICKLING FILTERS.

MR. HARRISON P. EDDY * (*by letter*). — Mr. Fuller's discussion clearly sets forth the premises upon which he bases his conclusion "that a trickling filter bed of not less than 6 ft. and not more than 7 ft. will in a great number of cases prove the most economical to use." He agrees that comparable data on the relative efficiency of trickling filters of different depths are very meager, and that there is no accepted method of comparing the purification effected by trickling filters in different localities.

Mr. Fuller states that in the absence of any definitely accepted method of comparing the efficiency of different filters, he has used the formulæ suggested to the Royal Commission by their chemist, Dr. George McGowan, explained at length in the Fifth Report of the Royal Commission, Appendix 4, pages 1-50. By the use of these formulæ Dr. McGowan and Mr. Colin C. Frye reached the following conclusion with respect to percolating filters of coarse or of medium to coarse material from 6 ft. to 9 ft. in depth (*Ibid.*, p. 22): "Within the above limits . . . the deeper the filter, the greater is the relative purification effected per cube yard of filtering material." It is surprising that Mr. Fuller, by the use of the same formulæ, should arrive at a diametrically opposite conclusion. It may be that they are not applicable under all conditions at sewage treatment plants in this country.

* Author's closure.

The method used by Dr. McGowan in arriving at these formulæ appears to be based on sound reasoning. There is a wide variation, however, in the value of the constants used in the formulæ as determined from tests upon different sewages, and Dr. McGowan states that the results are only approximate. He points out also that it is necessary to make corrections for certain sewages containing trade wastes. It may be that the formulæ should be radically modified when applied to Gloversville and Worcester, both of which cities contain unusual amounts of trade wastes.

It is certainly a fact that in the case of Filters G and H at Worcester, which, in Table 4 of Mr. Fuller's discussion, show 8 200 and 8 350 "purification units" per cubic yard per day, respectively, Filter G accomplished distinctly more work than Filter H. These filters differed only in the size of filtering material and during the period in question received almost identical quantities of comparatively fresh sewage from the Imhoff tank. The analyses quoted by Mr. Fuller show that the purification effected by Filter G was distinctly greater than that accomplished by Filter H, in spite of the fact that the "purification units" ascertained by Mr. Fuller by the application of the Royal Commission formulæ indicate the reverse to be true.

We have checked up Mr. Fuller's computations in Table 4, and find that the strength of the effluent from Filter G should probably have been 6.9 instead of 7.9, in which case the reduction in strength would have amounted to 86.8 units instead of 85.8, and the "purification units" per cubic yard per day would then be 8 330 instead of 8 200. After making this correction, however, the results would still indicate that Filter H had done somewhat more work than Filter G, which is contrary to the facts.

In obtaining these results for Filters G and H, Mr. Fuller has assumed that the oxygen consumed by the two-minute boiling test is equivalent to that which would be obtained by the English four-hour test, whereas comparisons made by Mr. Lanphear at Worcester show that the four-hour test gives results approximately one half those obtained by the two-minute boiling test. This correction would reduce the "strength"

of the influent about 40 per cent. Mr. Fuller has also omitted the factor of volatile suspended matter from the formula for calculating the strength of the effluent, which correction still further reduces the "purification units." The comparison of Mr. Fuller's values with our corrected values is as follows:

PURIFICATION UNITS PER CUBIC YARD PER DAY.

	Filter G.	Filter H.
Mr. Fuller's computations.....	8 330*	8 350
Corrected values.....	4 270	4 265

The "corrected values" change the relative purification effected by the two filters only slightly, but they show the need of caution in applying the Royal Commission formula.

In Table 3 of Mr. Fuller's discussion, it would appear that the 5-ft. Filter D at Worcester accomplished decidedly more work than the 7.5-ft. Filter F of the same material. Only 70 per cent. of the effluent samples from Filter D were stable, against 93 per cent. of the effluent samples from Filter F. If the same load per cubic yard had been applied to Filter F that was applied to Filter D, the number of "purification units" would have been quite different. A similar statement is made in the discussion on page 21 of Appendix 4 of the Fifth Report of the Royal Commission, which reads as follows: "At Leeds the purification effected was much less than at the other five places because the filter was not working up to its full power."

In the case of the Gloversville data presented in Table 2 of Mr. Fuller's discussion, too much value again appears to be indicated for the filter producing the poorest effluent. We call attention to the fact that whereas the 5-ft. filter shows approximately 50 per cent. higher value for the "purification units" than the 10-ft. filter, the quality of the two effluents is hardly comparable. Only approximately 37 per cent. of the samples of effluent from the 5-ft. filter passed the putrescibility test against 91 per cent. of the effluent samples from the 10-ft. filter, and 53 per cent. of the effluent samples from the 7-ft. filter.† In this connection we will quote again from the Fifth Report of the

* As corrected by H. P. E.

† See Gloversville report, p. III.

Royal Commission, Appendix 4, page 27, referring to the use of the formulæ proposed for ascertaining the "purification units," which reads as follows: "It must, however, be clearly understood that this proposal is only meant to apply to the case of good, or at all events, fairly good effluents. In the case of a bad effluent, it may be misleading, for as a general rule the more sewage liquor passed through a filter with a poor result, the greater the number of units of purification by this method of calculation."

Turning now to the Baltimore results in Table 6 of Mr. Fuller's discussion, we note that while the 6-ft. filter accomplished 20 per cent. more work than the 9-ft. filter by the "purification units," the relative stability, according to the Baltimore report cited (Table G, p. 67), was 20 per cent. higher in the case of the 9-ft. filter. There is much less difference between the character of the effluents from the 9-ft. and 12-ft. filters, which would indicate that the 9-ft. filter was the more economical. These filters, however, were in operation less than a year (August 1, 1907, to May 8, 1908), and it could hardly be expected that they would reach a condition to do their maximum work in this period of time, particularly in the case of the deeper filters. Examining the results of putrescibility tests in Appendix 2 (Table 5) of the Baltimore report, we find that in the case of the 9-ft. filter all but one of the effluent samples, after January 20, did not putrefy at all, and the same thing was true of the 12-ft. filter after January 6. In the case of the 6-ft. filter, however, less than 75 per cent. of the effluent samples after January 1 remained non-putrescible. In the case of the deeper filters it would appear that the purification was carried further than necessary to produce a non-putrescible effluent. How much further, the putrescibility test does not reveal. If the extent of purification sought be a non-putrescible effluent, a greater load could have been put upon the deeper filters with satisfactory results.

In Table 7 of Mr. Fuller's discussion, it appears that a 4.5-ft. filter at Baltimore accomplished 30 per cent. more work by "purification units" than a 7.5-ft. filter. The effluent from the 4.5-ft. filter was unsatisfactory, however, if we take a non-

putrescible effluent as the standard, the relative stability being only about 55 per cent., as shown in Table G, p. 68, of the Baltimore report. The purification accomplished by the 7.5-ft. filter is 24 per cent. greater than that accomplished by the 10.5-ft. filter, according to the "purification units," but the "strength" of the effluent from the 7.5-ft. filter is 73 per cent. greater than that from the 10.5-ft. filter.

An examination of the Lawrence data in Table 5 of Mr. Fuller's discussion shows that the 10-ft. filters produced much higher nitrification than the shallower filters, and that the "strength" of the effluent from the shallower filters is many times that of the 10-ft. filters. If the load upon the 10-ft. filters had been increased so as to give effluents of substantially the same quality as those from the shallower filters, the "purification units" accomplished by the 10-ft. filters would undoubtedly have been very materially increased and it seems quite probable that these values would equal or exceed those given for the shallower filters.

To summarize, we believe that our studies show that the English formulæ are not applicable to the wide range of conditions covered in Mr. Fuller's discussion and lead to erroneous conclusions.

Mr. Fuller states that the conclusion of the Royal Commission that the work accomplished by trickling filters is substantially the same per volume of material were presumably obtained with stale rather than with fresh sewage. In their "General Conclusions as to the Working Power of Different Types of Filter," on page 117 of the Fifth Report, the Royal Commission state with reference to well-settled sewage, "In this case, therefore, the process is comparable with the treatment of septic liquor upon percolation filters." The Royal Commission make no distinction between fresh and stale sewage, but it is fair to assume that the above statement applies to all conditions from comparatively fresh to extremely septic.

Our method of comparing the work done by trickling filters of different depths was to ascertain the relative stability of the effluents when equal loads of unoxidized nitrogen per cubic yard of filter were being applied. We recognize that this is an arbi-

trary method, but we fail to see why it should lead to erroneous conclusions when applied to the same kind of sewage for a given locality. As a means of comparing filters of different depths in different localities, it might not be applicable.

In order to make our depth comparisons, we were obliged to select periods in which the loads applied per unit volume of filter were as nearly alike as possible. The periods referred to in Table I were as follows:

Locality.	Filter No.	Period of Operation.	Reference.
Gloversville, N. Y.	3	Aug. 29-Oct. 22, 1908	Gloversville Rpt., Append. K
Gloversville, N. Y.	2	Sept. 2-Oct. 22, 1908	Gloversville Rpt., Append. J
Gloversville, N. Y.	1	*Oct. 20-June 28, 1908	Gloversville Rpt., Append. I
Worcester, Mass.	D	Sept., 1909-Sept., 1910	Worcester Sewer Dept. Rpt. 1910, p. 748
Worcester, Mass.	F	Sept., 1909-Sept., 1910	Worcester Sewer Dept. Rpt. 1910, p. 748
Worcester, Mass.	E	†Aug. 18-Nov. 26, 1909	Worcester Sewer Dept. Rpt. 1909, p. 1049
Worcester, Mass.	H	Aug.-Nov., 1911	Worcester Sewer Dept. Rpt. 1911, p. 511
Worcester, Mass.	G	Aug.-Nov., 1911	Worcester Sewer Dept. Rpt. 1911, p. 510
Lawrence, Mass.	247	1904-1906	State Bd. of Health Rpt. 1908, p. 378
Lawrence, Mass.	248	1904-1906	State Bd. of Health Rpt. 1908, p. 378
Lawrence, Mass.	248	1907-1910	State Bd. of Health Rpts. 1908, p. 378; 1909, p. 298; 1910, p. 258
Lawrence, Mass.	135	1904	State Bd. of Health Rpt. 1908, p. 377
Lawrence, Mass.	136	1907 and 1908	State Bd. of Health Rpt. 1908, p. 377
Lawrence, Mass.	136	1909	State Bd. of Health Rpt. 1909, p. 298
Lawrence, Mass.	136	1904-1906	State Bd. of Health Rpt. 1908, p. 377
Lawrence, Mass.	135	1907, 1909, 1910	State Bd. of Health Rpts. 1908, p. 377; 1909, p. 298; 1910, p. 258
Lawrence, Mass.	135	1908	State Bd. of Health Rpt. 1908, p. 377
Lawrence, Mass.	135	1907-1910	State Bd. of Health Rpts. 1908, p. 377; 1909, p. 298; 1910, p. 258

* Given as three months in Table I instead of eight months, by typographical error.

† Given as one year in Table I through an error in copying.

Mr. Fuller suggests that our general conclusion based on Gloversville and Worcester may not be justified on account of the fact that the sewage of these two cities contains unusual amounts of manufacturing waste. In this connection we might state that the Royal Commission in arriving at the same conclusion considered the results obtained at Birmingham, Bradford, Leeds, Leicester, Manchester and Sheffield, all of which have substantial amounts of manufacturing wastes of one kind or another in their sewages.

Mr. Fuller states that our data are at variance with those from Baltimore and those from Hanley and Leeds, England, as summarized by Kinnicutt, Winslow and Pratt, p. 332. In regard to Baltimore, we are unable to apply our method of comparison to the results obtained from the trickling filters of different depths because similar loads were not applied per unit volume of filtering material. We do not consider that the Baltimore results prove that filters 10 or 12 ft. deep will not produce a non-putrescible effluent at as high a rate of dosing per unit volume of filtering material as can be applied to shallower beds.

The Hanley filters cited by Mr. Fuller were composed of $\frac{1}{8}$ -in. to $\frac{1}{4}$ -in. filtering material, 1 ft., 2 ft., 3 ft. and 4.5 ft. in depth, respectively. These filters are not applicable to this discussion on account of the shallow depths and the small size of material. In the case of a sand filter, the suspended matter of the sewage applied must be retained very largely at or near the surface of the bed and it can never be carried through the filter. In the case of a trickling filter of coarse material properly operated, the suspended matter is carried down into the bed, and after certain bacterial changes have come about it is eventually discharged with the effluent. This is one reason why a trickling filter may be able to accomplish the same amount of work whether it is arranged in the form of a shallow or as a deep bed. With such fine material as used in the Hanley filters referred to above, surface clogging is quite certain to result.

The Leeds filters cited by Mr. Fuller were of coarse coke 3.5, 2.5 and 2.5 ft. deep, respectively, one above the other and were operated for a period of six months with crude sewage.*

* See Royal Commission, — Fifth Report, p. 70.

These filters were dosed with the same quantity of unsettled sewage per unit of area and the effluent from the total depth of 8.5 ft. was still a very unsatisfactory one. We do not understand that these results are at variance with our conclusion. It is, of course, a fact that the bulk of the suspended matter of the crude sewage was retained in the upper filter.

It is pretty generally agreed that sewage should be well settled preliminary to its treatment by trickling filters. We had understood that the chief trouble from clogging at Reading was due to an abnormal amount of suspended matter being carried out of the large settling tank at Milmont on account of the septic action in this tank during the summer and fall. It is true that there is a greater tendency towards surface clogging with the deeper bed on account of the greater quantity of sewage applied per unit of superficial area, as pointed out in our original paper. Our observations and tests, however, lead us to believe that a 10-ft. filter of fairly coarse material is not too deep if a well-settled sewage of average strength and character is applied with efficient distribution. If the accumulation of clogging matter is such as to prevent the free circulation of air, it will seriously affect the efficiency of the filter. Organic growths may also complicate the situation. Such difficulties can be largely avoided by a proper control of the dosing and resting of the filter. The importance of wise supervision of operation of all trickling filter plants cannot be overestimated.

Mr. Fuller's discussion and application of the McGowan formulæ and the difficulties of applying them to such diverse conditions as herein pointed out, emphasizes more strongly than the writer realized the urgent necessity of experiments such as those being carried out by Mr. Clark at Lawrence. A demonstration of what trickling filters of different depths will actually do when so dosed as to produce effluents of practically uniform quality will be more convincing than the cut and try method of comparison adopted by the writer or the formulæ of Dr. McGowan, which Mr. Fuller prefers. The writer appreciates Mr. Fuller's discussion. It is to be hoped the work described by Mr. Clark will be continued by him and that similar tests, if possible on a somewhat larger scale, will be undertaken by others.

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**DISCUSSION OF INSURANCE AS AN AID TO
ENGINEERS.**

BY MESSRS. F. B. SANBORN AND N. H. DANIELS.

PROF. F. B. SANBORN. — I would like to say a word or two complimenting Mr. Daniels on his review of fire prevention. I believe that general reviews of the essentials of fire prevention help to keep the subject before us and to improve conditions. There are also one or two things that I noted during the lecture that I wish to refer to. One is that I should like to modify the title just a little. Instead of saying "Insurance as an aid to engineers," I would like to put it, "Insurance as a benefit to clients of engineers." I mean by that, that I think the large benefit comes in the saving of money, which is of especial interest to clients of engineers.

I sometimes think that as to engineers' work, this question of fire prevention brings in certain annoying and difficult problems. One is, for example, that an ordinary engineer, working in a consulting capacity and doing a fair amount of work, has a particular design of a plant that involves considerable fire prevention. Shall he try to put that through himself? Shall he have the insurance companies tell him how to do it? Or shall he hire an expert to help him? Certainly if an engineer attempts to do it all himself, and tries to study out many particulars which he may never use again, there is some waste of

time and effort. But as to the assistance that we can get by going to the bureaus, I pretty fully agree with Mr. Daniels. There is much help from that source which can be utilized.

I should like to modify slightly the emphasis that he has seemed to put on the value of labels. As a result of my own experience, which has included eleven years in inspecting work and ten years intermittently in consulting practice, I believe that, theoretically, this idea of labeling is right, and I am not prepared to say that it is wrong in serious respects, but as it is carried out at the present day, I will say that there is much complaint, and consequently I am inclined to be a little incredulous. One common complaint seems to be that labeling has become a monopoly. Another is that it is a dreadfully dragged-out affair; that to put a new article through and have it accepted the first time takes from six months to a year and a half, and that often you have to go to Chicago and push it right through step by step. I realize that Mr. Daniels might say that these stories are probably exaggerated, but I happen to be familiar with the business of one company that is making a product that has to go through this process of approval, and the treasurer tells me that it is a long story to get first approval; and he says that it means an expenditure of considerable money. The question may fairly be raised, Should not the expense of labeling be much reduced?

In large manufacturing corporations like the Amoskeag Mills, the Pacific Mills and others, labeling may properly be dispensed with. They can build fire doors just about as well as people who make a business of it, because, as Mr. Daniels has pointed out, they can get specifications from the insurance companies, and they can put men on that work who will be on it frequently, perhaps make ten or a dozen doors every year. Those doors won't be labeled but they will be all right. Perhaps I have made my emphasis too bold. All I wanted to modify from what Mr. Daniels said would be that as a rule if one was not fully familiar with details he might select labeled doors, but I wouldn't make the requirement for labeling too sweeping.

Now, on the cost of insurance: I didn't get fully the cost for the plant that Mr. Daniels showed and mentioned \$49. Do I

understand that \$490 is the cost per hundred thousand dollars of insurance?

MR. DANIELS. — I am not entirely sure as to the amount of insurance carried. I was merely speaking of a lump sum that it cost a particular station. I only meant to say, of course, that under those conditions it might have cost that particular company \$400 a year. It is actually costing \$49 a year on the amount that it is carrying.

PROFESSOR SANBORN. — I wasn't sure but you meant a rate. I understand that the cheapest rate you mentioned is seven hundredths of one per cent., and the highest rate is some other per cent.; the average rate for power houses, I assume, is perhaps one per cent., or \$1 000 for \$100 000. This is high compared with the amount that is paid even on large cotton mills. Take those even like the ones that burned in Salem. Their cost for insurance is less than \$100 per \$100 000 insurance, and I think power houses are paying an excessive amount on insurance, due to the fact that a great many power plants have to place this insurance through some of the insurance bureaus that have kept the rates up too high. In the Factory Mutual Companies, where we get the cheapest insurance, the cost would be about one tenth of 1 per cent., but they are not inclined to take city power plants; they take principally power plants of large manufacturing interests.

In closing, I wish to emphasize one element of good fire prevention which Mr. Daniels touched upon but did not bring out as fully as I would like to see it. Besides the three essential elements, namely, construction, occupancy and protection, I would give prominence to a fourth one, — management. You can have the other three things, but, if the plant is not well taken care of, well managed, the risk is increased and a higher rate is apt to be charged. I should emphasize management as a very important factor.

MR. DANIELS. — I want to make one or two observations on the remarks which have just been made.

It is true that there has been criticism of labeled service, and manufacturers occasionally complain of the requirements placed upon them. I have never had occasion to investigate the

matter with care, but in three or four cases which I have looked into the trouble seemed to be as much with the manufacturers and the article which they were trying to have labeled as with the labeled service. The point which I wish to make is that the Underwriters' label is like a trade mark of a well-known concern. You have no question regarding the quality of the article on which you find it. A fire door which is made according to specifications will perform efficient service, but the only men who are sure it is of standard construction are the ones who made the door or who saw it made. You or I or an insurance inspector finding an unlabeled door cannot tell whether it is a good one or not, but when we find one which bears the Underwriters' label, all doubt is removed and we are justified in giving it full credit.

I have purposely avoided saying much to-night about the cost of insurance or methods of reducing it. This is a very interesting and profitable study of itself. We balance the saving in the cost of fire insurance and the reduced chance of fire damage against the added cost due to the better construction. The amount which we pay for fire insurance depends on two things,—the rate and the amount of insurance carried. Evidently as the value of the property becomes greater the amount which we pay because of poor construction increases correspondingly and the amount which can be expended to improve the property becomes correspondingly greater. It sometimes happens that a building is designed having in mind the possibility of extending it from time to time, due to the growth of the business. There may be changes which will reduce the cost of fire insurance which it will not pay to consider at the start as the reduction in insurance is not sufficient to justify the added cost. As the size of the property increases and its value becomes greater, the amount which is paid by reason of the original deficiencies will increase correspondingly until a point is reached where it will pay to make the changes necessary to effect the saving in insurance.

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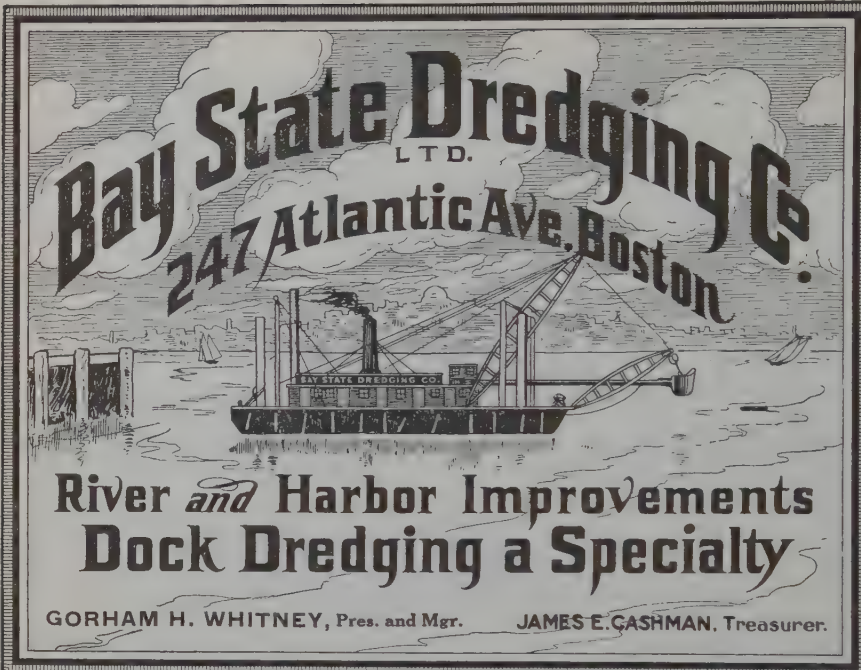
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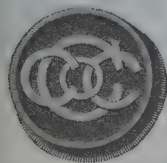
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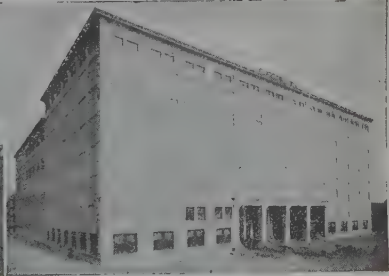
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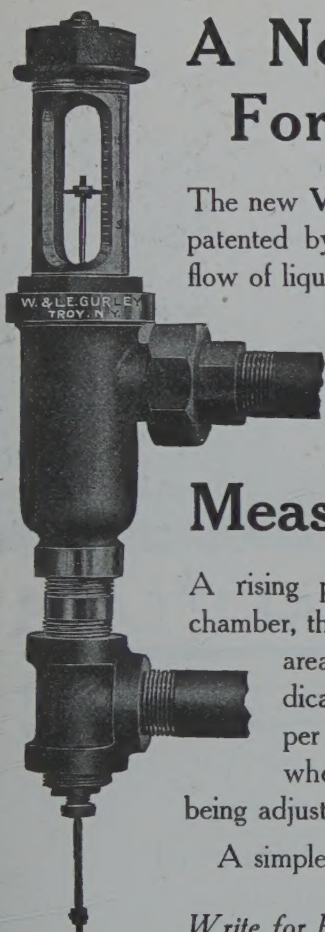
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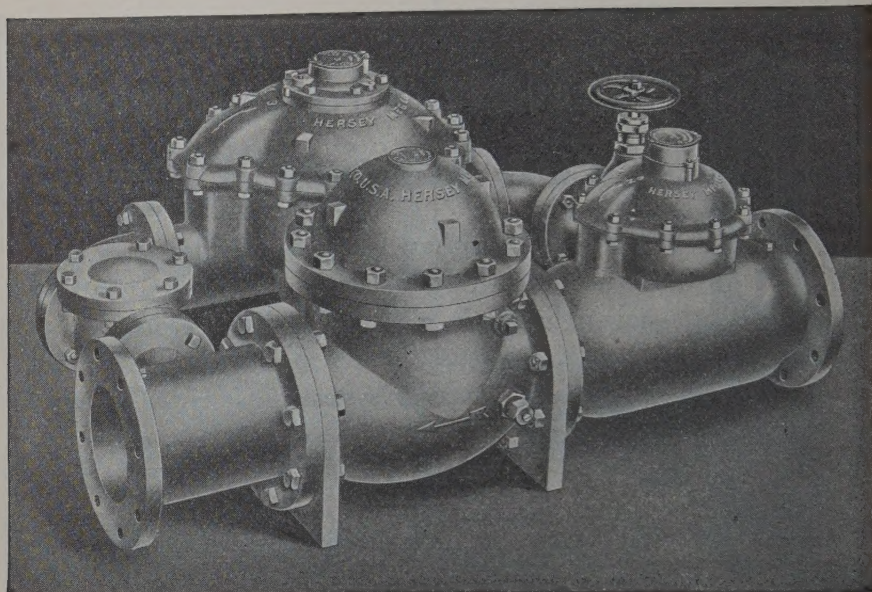


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